

July 14, 2004

MEMORANDUM FOR: Edward E. Carlson
NGS Pacific Region Geodetic Advisor

FROM: Charles W. Challstrom
Director, National Geodetic Survey

SUBJECT: INSTRUCTIONS: GUAM FBN GPS SURVEY, 2004 (GPS-1987)
Task Number: B8K3BPS-P00

GENERAL:

The National Geodetic Survey (NGS), in accordance with the NGS Strategic Plan, is engaging in a campaign of observing stations of the Federal Base Network (FBN) to complete the ellipsoidal and orthometric height components of the FBN. This project will upgrade the horizontal and vertical geodetic control for the Commonwealth of the Northern Mariana Islands. It will disseminate the updated data to the islands, as well as commercial vendors. The goals are to establish a High Accuracy Reference Network (HARN)/Cooperative Base Network (CBN) with 5-10 km spacing on each island, establish geodetic quality leveling network on each island, and establish an absolute gravity station or relative gravity on all the islands.

PURPOSE:

In order to meet America's accelerating positioning and navigation needs, the existing coordinate reference system must be continually enhanced to provide the accessibility and high accuracy required for use with GPS. The digital revolution in mapping, charting, and surveying requires a National Spatial Reference System (NSRS) consisting of, among other components, a network of monumented points having four-dimensional positions. The FBN fulfills the requirements for this component. NGS is charged with the Federal responsibility for establishment, observation, monitoring, and maintenance of the FBN. The FBN provides the critical network foundation for an accurate, consistent, reliable NSRS.

The NSRS, in turn, provides the common geographic framework for America's spatial data infrastructure. As such, the NSRS serves as the basis for mapping, charting, navigation, boundary determination, property delineation, infrastructure development, resource evaluation surveys, and scientific applications, including crustal motion monitoring, modeling of flooding,

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storm surge, pollution trajectories, and agricultural runoff. A modernized, accurate, consistent, reliable NSRS is of enormous benefit to state, county, tribal, local, and Federal authorities, as well as to the private sector. The project will be performed under the technical management of NGS.

This Guam FBN GPS survey and geodetic leveling campaign will provide the horizontal and vertical integration and positional improvements required to support the diversity of GIS, engineering, geophysical, charting and mapping applications required within the National Ocean Service (NOS), other Federal and local government agencies, and private sector requirements. Using the specifications consistent with the NGS Height Modernization initiative, NGS will conduct an integrated survey program to provide positional accuracies better than 2 cm in the horizontal and 2 cm in the ellipsoidal components.

SPECIFICATIONS:

Project requirements for the FBN and CBN observations are to ensure 2-centimeter local accuracy in the horizontal component, as well as 2-centimeter local accuracy for the ellipsoid heights.

Data from the CORS, GGUG and GUAM on Guam plus CNMR on Saipan, if needed, are to be used in the processing.

Tasks to accomplish are to increase the densification by implementing a FBN/Cooperative Base Network on Guam. Locate and survey as FBNs at least 20 marks already GPSed that would support the local surveyor and GIS communities.

Conduct geodetic leveling between the tidal bench marks, some FBN, some CBN and CORS stations on Guam. Conduct a network adjustment on the vertical network and on the GPS network to be included in NGS's IDB.

Positions and data for the National CORS are available from the NGS web site.

General specifications for the project are as follows. Observe 3 sessions of 5.5 hours each on a framework of stations, the FBN/CBN stations. All the UDN stations are within 5 km of a FBN/CBN station, thus two 1-hour sessions at least 4 hours different and on different days would be more than sufficient to achieve 2 cm accuracy in the height component.

The FBN/CBN observing scheme shall be arranged so that for each station, the start time of one of the observing sessions shall be at least 4 hours different from the other two.

Each FBN station must be occupied at least three times - twice at one observing window and once at the other. The observing scheme shall be arranged to ensure that adjacent FBN and adjacent CBN stations are directly connected in at least one observing session, and at least half of all base lines are repeated. The CORS base lines will be repeated. CORS data will be used throughout the project.

Each FBN, if not a first- or second-order bench mark, must be tied to two different bench marks. This bench mark tie requirement can be satisfied in one or two sessions.

In general, station occupation and observing procedures must be carried out according to appropriate sections of the "NGS Operations Handbook" and the current applicable receiver field manuals. Data formats and digital file definitions are given in "Input Formats and Specifications of the National Geodetic Survey Data Base," Volume I. Horizontal Control Data, Federal Geodetic Control Subcommittee, September 1994, revised and reprinted November 1998. Success in meeting the accuracy standards will be based on repeatability of measurements and adjustment residuals.

General specifications for the project are given in "Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques," Version 5.0: dated May 11, 1988, reprinted with corrections August 1, 1989. Specific project criteria and deviations from the general specifications are given in the sections that follow.

Data Acquisition - Data collection must be accomplished as specified in the appropriate dual-frequency receiver field manuals in the compressed mode at a 15-second epoch collection interval. The GPS receivers must be dual-frequency and full-wavelength. Track satellites down to a 10-degree elevation angle.

Record weather data just before, immediately after, and at the mid-point of each session. Meteorological data shall also be collected immediately after an obvious weather front passes during a session and immediately before it passes, if possible. Pressure and relative humidity measurements must be made near and at about the height of the GPS antenna phase center. Indicate in the log the location of the barometer and psychrometer.

Note: It is not required to collect meteorological data. However, collection of met data is encouraged if appropriate meteorological instruments are readily available; NGS does not recommend buying meteorological instruments solely for this purpose. The data may be useful during the analysis phase, particularly when atmospheric conditions are abnormal or highly variant. It may be possible to avoid reobservations through re-processing with observed meteorological data.

Survey operations shall be conducted with due regard to the safety of personnel and equipment. Contact with the airport traffic control tower is mandatory during surveys at any controlled airports.

Vector Computations - Data management, quality review of collected data, and final vector processing for the FBN/CBN survey will be accomplished using PAGES. Vectors shall be computed in the International Earth Rotation Service Terrestrial Reference Frame (ITRF) system, using the most current epoch and precise IGS ephemerides. Use 30-second epoch intervals for data processing. Monument positions will be used for CORS when available, otherwise, antenna reference point (ARP) positions will be used. Edward Carlson, the Pacific Region Geodetic Advisor, will be responsible for the processing.

The data will be processed in 24-hour sessions (or slightly longer if the observation session crosses 0000 UTC) in order to utilize the 24-hour data sets collected at the CORS. The “fixed baseline” option in PAGES will be used to compute direct baselines to the CORS. The “fixed baseline” scheme will depend on the location and reliability of the CORS used in this project.

For stations where weather data are not available, or are suspect, predicted values will be computed and used based on the station's latitude, height above mean sea level, and time and day of year. Use 15 degrees as the cutoff elevation angle in data processing. A cutoff angle of 10 degrees may be used when necessary to improve results.

The type of final solution, L1 versus ion-free, will depend on the length of the vectors. For vectors which are less than 10 km in length, the final reduction will consist of a L1 fixed solution. These vectors will be computed in a separate processing session from the longer vectors computed in an ion-free solution.

In general, vectors greater than 10 km in length are to be computed in an ion-free fixed, or partially-fixed, solution. In all cases, integer ambiguities will be fixed for each vector whenever possible. The quality of collected data shall be determined from the plots generated from PAGES, by analysis of repeated vectors and/or comparison of station positions, and free adjustment residuals and/or loop misclosures. In addition, a constrained adjustment constraining all CORS will be performed.

Edward Carlson will perform all quality checks for conformance with NGS format standards such as executing software programs COMPGb, OBSCHK, and OBSDES. The final ITRF vectors will be assessed and transformed to the NAD 83 coordinate system using program ADJUST.

The data and results will be submitted to the Observation and Analysis Division. All B-files and G-files must be complete, including *25* and *27* records.

Station Descriptions - Station recovery notes must be submitted in computer-readable form using WDDPROC software. Include the name, address, and, if public ownership, the telephone number of the responsible party. Do not include the telephone numbers of private property owners.

Special Requirements - Antenna set-up is critical to the success of this project. Fixed-height tripods are preferred for all receivers. The plumbing bubbles on the antenna pole of the fixed-height tripod must be shaded when plumbing is performed. They must be shaded for 3 minutes before checking and/or re-plumbing. Also, the perpendicularity of the poles must be checked at the beginning of the project and any other time there is suspicion of a problem.

When a fixed-height tripod is not used, the height of the antenna must be carefully measured to prevent station set-up blunders from occurring. Tribrachs used for these set-ups must be checked and adjusted when necessary. Totally independent measurements of the antenna height above the mark in both metric and English units must be made before and after each session. Someone other than the observer must check the measurement computations by carefully comparing measurements and then entering his/her initials on the log.

Some GPS antennas have detachable ground planes and radomes. In order to help identify what exactly was used at a particular site, it would be useful to have a snapshot of the setup. All observers should take a photograph of the setup, if possible, with a close-up of the antenna as viewed from the side.

In addition, digital photographs of each survey mark are required. See "Requirements for Digital Photographs of Survey Control," Version 10, January 25, 2002, for specific information.

Also, a rubbing of the stamping of the mark must be made at each visit to a station. If it is impossible to make a rubbing of the mark, a plan sketch of the mark must be substituted, accurately recording all markings.

Also, for each station visited, a visibility obstruction diagram must be prepared and the TO-REACH description carefully checked for errors or omissions.

Lastly, the following must be recorded at each occupation of a station:

- (1) receiver manufacturer,
- (2) antenna manufacturer,
- (3) receiver model number (part number),
- (4) antenna model number (part number),
- (5) the complete serial number of the receiver, and
- (6) the complete serial number of the antenna.

Success of this project requires that the highest quality GPS data be collected. Therefore, during each station occupation, the operators shall carefully monitor the operation of the receivers. Any irregularities in the data due to equipment malfunction, DOD adjustment of the satellite orbit, obstructions, etc., must be reported to the Project Development Branch, N/NGS2, as soon as possible and noted on the observing log. If the quality of observations for an observing session is questionable, notify the Project Development Branch immediately.

The survey team shall not depart the project area until they have quality reviewed all data and advised N/NGS21.

GPS DATA:

A project report and data listed in Annex L of "Input Formats and Specifications of the NGS Data Base" and in the attached addendum for the adjustment portion of the project must be transmitted. Any data considered suspect as to quality in achieving accuracy standards should be sent via FedEx immediately for office review. Backup of transmitted data must be held until notified by the Field Operations Branch, N/NGS41.

The data set collected during the project shall be named "mifb043d.1115". All records in connection with this project shall be titled "GUAM FBN GPS SURVEY, 2004". The project number (accession number) is GPS-1987.

LEVELING DATA FORMATS AND HANDLING:

- A. Leveling data will be submitted in "Blue Book" format (see "Input Formats and Specifications of the National Geodetic Survey Data Base," Volume I. Horizontal Control Data (revised November 1998) and Volume II. Vertical Control Data, Federal Geodetic Control Subcommittee, September 1994) to NGS Headquarters on floppy disks. Floppy disks shall contain the final version of the following files: HGF, HGZ, and HA in direct access format and RPT and ABS in sequential format. Data shall be submitted to the Observation and Analysis Division within 30 days of completion of the project.
- B. All bench marks established during this leveling project must be plotted on the best available map and the positions of bench marks scaled using standard procedures, if the bench mark position cannot be determined with a GPS instrument. One set of these maps shall be submitted with the data. Those recovered bench marks which do not have PIDs will be treated as new marks.

LIAISON:

Liaison must be maintained with designated offices at the National Geodetic Survey headquarters located at:

1315 East-West Highway
Silver Spring, Maryland 20910-3282

Questions and problems concerning survey field operations should be directed to:

Elizabeth B. Wade
Chief, Observation and Analysis Division

N/NGS4, SSMC III, Station 8558
Telephone: 301-713-3176, ext. 103
Fax: 301-713-4327
e-Mail: Libby.Wade@noaa.gov

Questions and problems concerning adjustment processing should be directed to:

Maralyn L. Vorhauer
Observation and Analysis Division
N/NGS4, SSMC III, Station 8562
Telephone: 301-713-3176, ext. 104
Fax: 301-713-4327
e-Mail: Maralyn.Vorhauer@noaa.gov

Questions and problems concerning vector processing should be directed to:

Julie Prusky
Field Operations Branch
Observation and Analysis Division
N/NGS4, SSMC III, Station 8458
Telephone: 301-713-3215, ext. 106
Fax: 301-713-4323
e-Mail: Julie.Prusky@noaa.gov

Questions and problems concerning using CORS data in processing should be directed to:

Miranda Chin
Geosciences Research Division
N/NGS6, SSMC III, Station 9114
Telephone: 301-713-2844, ext. 125
Fax: 301-713-4475
e-Mail: Miranda.Chin@noaa.gov

Questions and problems which could affect the technical adequacy of the project should be directed to:

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Guam contact people:

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ADDRESS

Keep N/NGS2 informed of the party's post office, physical address, and telephone number at all times.

PUBLICITY:

See "NGS Operations Handbook," Section 1.4.1.

EXPENSES:

Travel expenses for this project will be charged to task number B8K3BPS-P00.

TRAVEL:

Travel and per diem are authorized in accordance with Civilian Personnel Per Diem Bulletin Number 226. Current per diem rates were effective October 1, 2003.

ACKNOWLEDGMENT:

Please acknowledge receipt of these instructions in your Monthly Report.

cc: N/NGS - D. Zilkoski
N/NGS - S. Misenheimer*
N/NGS - J. Blackwell
N/NGS1 - G. Mitchell
N/NGS11 - K. Fancher
N/NGS1x1 - E. Carlson
N/NGS21 - S. Frakes
N/NGS21 - R. Anderson
N/NGS21 - D. Hendrickson
N/NGS22 - T. Soler
N/NGS4 - J. Olsen
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N/NGS4 - M. Vorhauer
N/NGS4 - D. Hoar
N/NGS4 - J. Prusky
FGCS MEMBERS*
Paul Santos - Division of Land Management
Thomas Condon - Duenas & Associates, Inc.

* first page only

Attachment 1

GUAM 2004 LEVELING NETWORK

LEVELING CONNECTIONS:

Tie leveling to existing bench marks, as described in the "Geodetic Leveling Manual," is required. Leveling will be performed to every existing United States Geological Survey (USGS) bench mark set in 1962-1963. The island of Guam has approximately 140kms of leveling. The leveling will be tied to 163 0000 TIDAL 4 and 163 0000 TIDAL 6 which are existing tidal bench marks at Apra Harbor. New marks are being set as replacement marks to which leveling will be done. CORS site reference stations and all other benchmarks are in the process of being set.

All High Accuracy Reference Network (HARN) control points within 4 km of the leveling route and all other existing NSRS horizontal control within 1 km of the leveling route will be connected to this project if possible.

LEVELING SPECIFICATIONS:

The line shall be leveled in both directions to first-order, class II standards. Leveling in one direction is acceptable when leveling between old bench marks, provided the newly observed elevation difference agrees with the previous difference within tolerance limits. When new marks are set, or the newly observed elevation difference between two old marks does not agree with the previous difference within tolerance, one side of the new or moving mark must be leveled in both directions.

In addition, if multiple new marks are set between old marks, all but one section between the old marks are to be leveled in both directions. Specifications and other technical considerations for this project are given in the "NGS Operations Handbook," "Geodetic Leveling Manual," "Bench Mark Manual," and "Interim FGCS Specifications and Procedures to Incorporate Electronic Digital/Bar-Code Leveling Systems."

MARK SETTING:

In general, the two CORS reference marks must be suitable for GPS occupation and be located within 1 km of the CORS antenna site. They must be at least B-stability, with A-stability preferred. The minimum quality mark set shall be a GPS 3-D monument. The CORS mark should be set as close as possible to the CORS antenna. These marks are not established to obtain azimuth with optical surveying equipment. The purpose of these marks is to provide redundant reference marks for referencing the CORS antenna at the facility.

LEVELING PROJECT TITLE, HGZ NUMBER, AND JOB CODE:

A. The leveling project title, HGZ number, and job code shall be named, respectively:

GUAM 2004

L-26623

**DATA TO BE SENT TO HEADQUARTERS RELATING TO
THE ADJUSTMENT PORTION OF
FBN/CBN PROJECTS**

Free adjustment in NAD 83 (UNIX run).

Plots of the free adjustment created by running “plotres_prompt.bsh” on a UNIX server. Plots require a printer that supports postscript. The output file (long.out) contains a list of residuals which may be sorted using the following commands:

```
vi long.out
:1,$ !sort +0.47 (sorts horizontal residuals)
:1,$ !sort +0.71 (sorts vertical residuals)
```

or

the XYZ_enu program output.

(OPTIONAL) Constrained horizontal adjustment holding NGS CORS positions and ellipsoid heights.

Final combined Blue Book file (ASCII required) with *86* records.

Final description file (DDPROC format required.)

Final G-file (ASCII required.)

OBSCHK output.* **

CHKDDESC output.*

OBSDES output.*

COMPGB output *

* Any errors or warning messages must be explained.

** Errors relating to incomplete *86* records are acceptable.